

Potamocorbula and *Corbicula* biomass, grazing, and recruitment patterns.

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A collaborative study between CA Department of Water Resources and USGS using currently or previously collected benthic samples in two sampling programs:

Temporal Studies - Monitoring



Map based on long and lat. Color shows details about Panel. The marks are labeled by State. The data is filtered on plan, which keeps CA and CT. The view is filtered on Panel, which keeps Monitor May 2010.

Spatial Studies - GRTS



Conceptual Model: Shifting X2 down bay in fall will reduce the grazing impact of *Potamocorbula* within the low salinity zone.

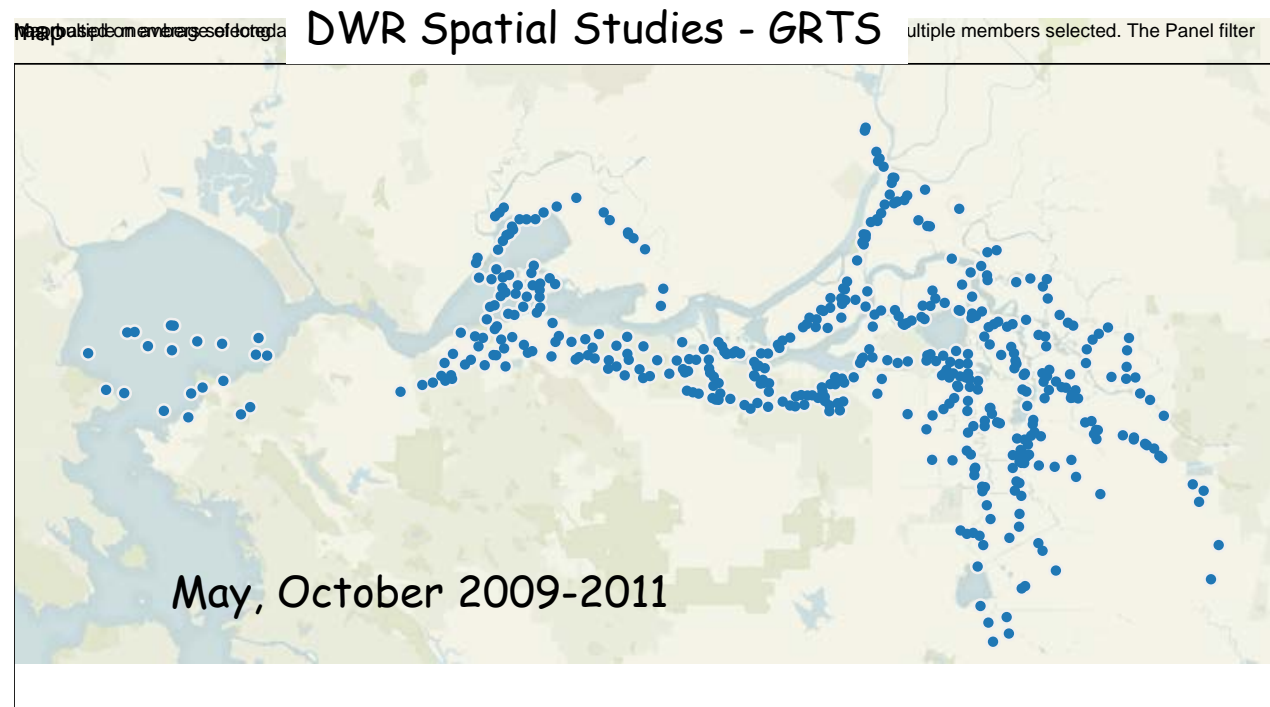
Results - Fall 2011 grazing rate was lower than in previous two years in LSZ and lower than any year since 2001 in Grizzly Bay shallows.

Questions that will be addressed:

1. Was grazing rate low enough to reduce pressure on phytoplankton biomass? - *in some areas yes*
2. Was the clam reduction due to spring or fall population dynamics? Mortality? Recruitment? Growth Rate? - *fall recruitment*
3. How did bivalve distribution and grazing rate differ in 2006 and 2011? - *primarily timing of recruitment*

We use the GRTS spatial data to extend our observations to areas not previously sampled, to estimate the spatial scale that is represented by the monitoring station data, and to supply needed spatial resolution for numerical models.

Dual use for data -
ecological studies
and numerical model
input



GRTS: generalized random teselated stratified

We use the DWR monitoring station data for its temporal resolution and historical record. The combination of these data collections allows us to examine the mechanisms of population change.

We will focus
on two
monitoring
stations today
- D7 and D4



Map based on long and lat. Color shows details about Panel. The marks are labeled by SiteID. The data is filtered on clam, which keeps CA and CF. The view is filtered on Panel, which keeps Monitor May 2010.

A note on filtration rate, grazing rate, and why you will see both values.

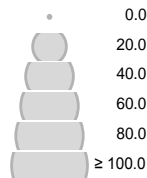
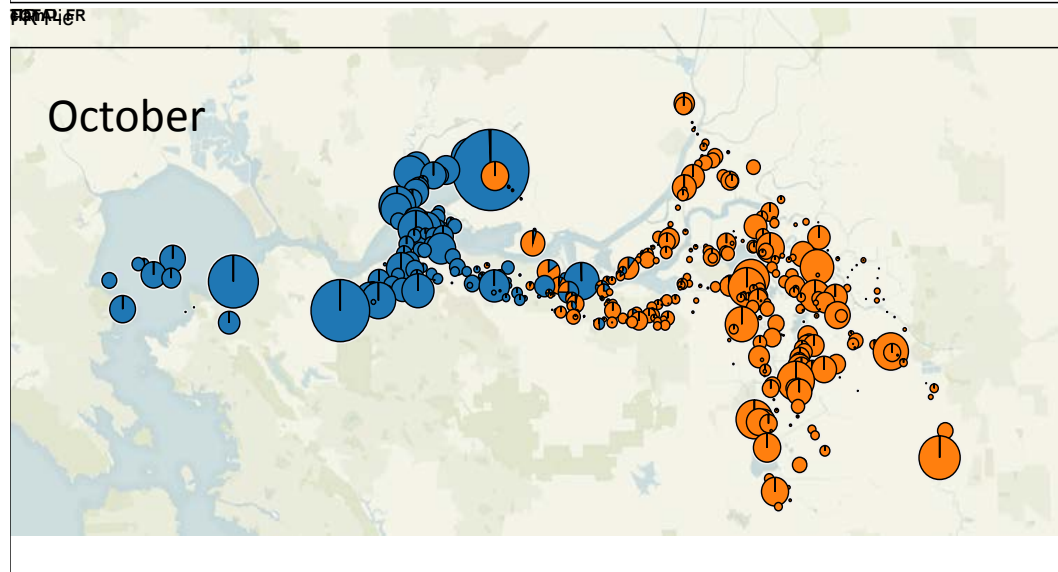
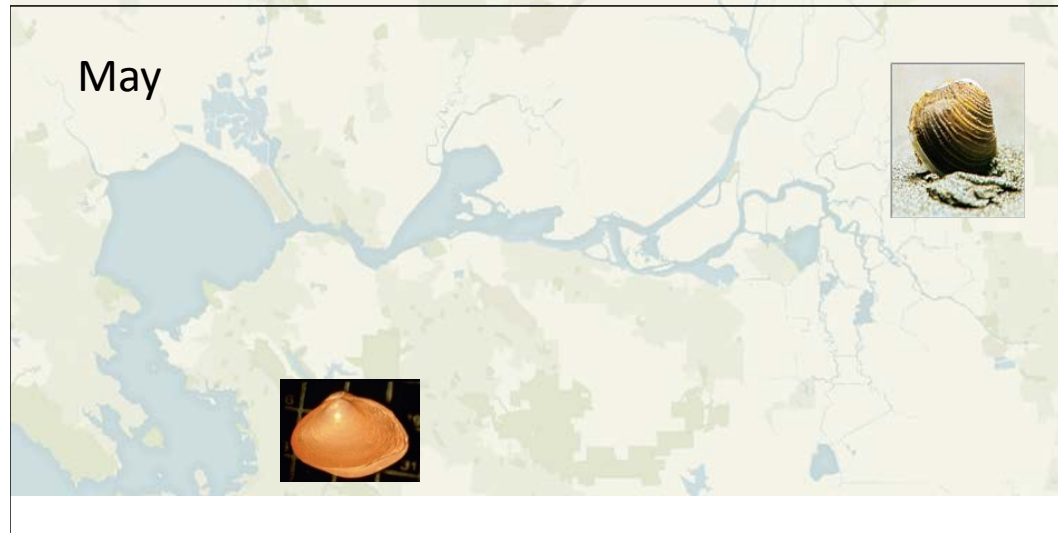
Filtration Rate (FR) = pumping rate \times biomass ($\text{m}^3/\text{m}^2/\text{day}$ = m/d) Maximum rate possible

Grazing Rate (GR) = FR \times correction for concentration boundary layer (m/d). Lower but valid estimate.

GR/FR Turnover Rate (GRT0) = FR and GR normalized by depth ($/\text{day}$). Makes the values mechanistically comparable between stations and allows direct comparison to phytoplankton growth rates.

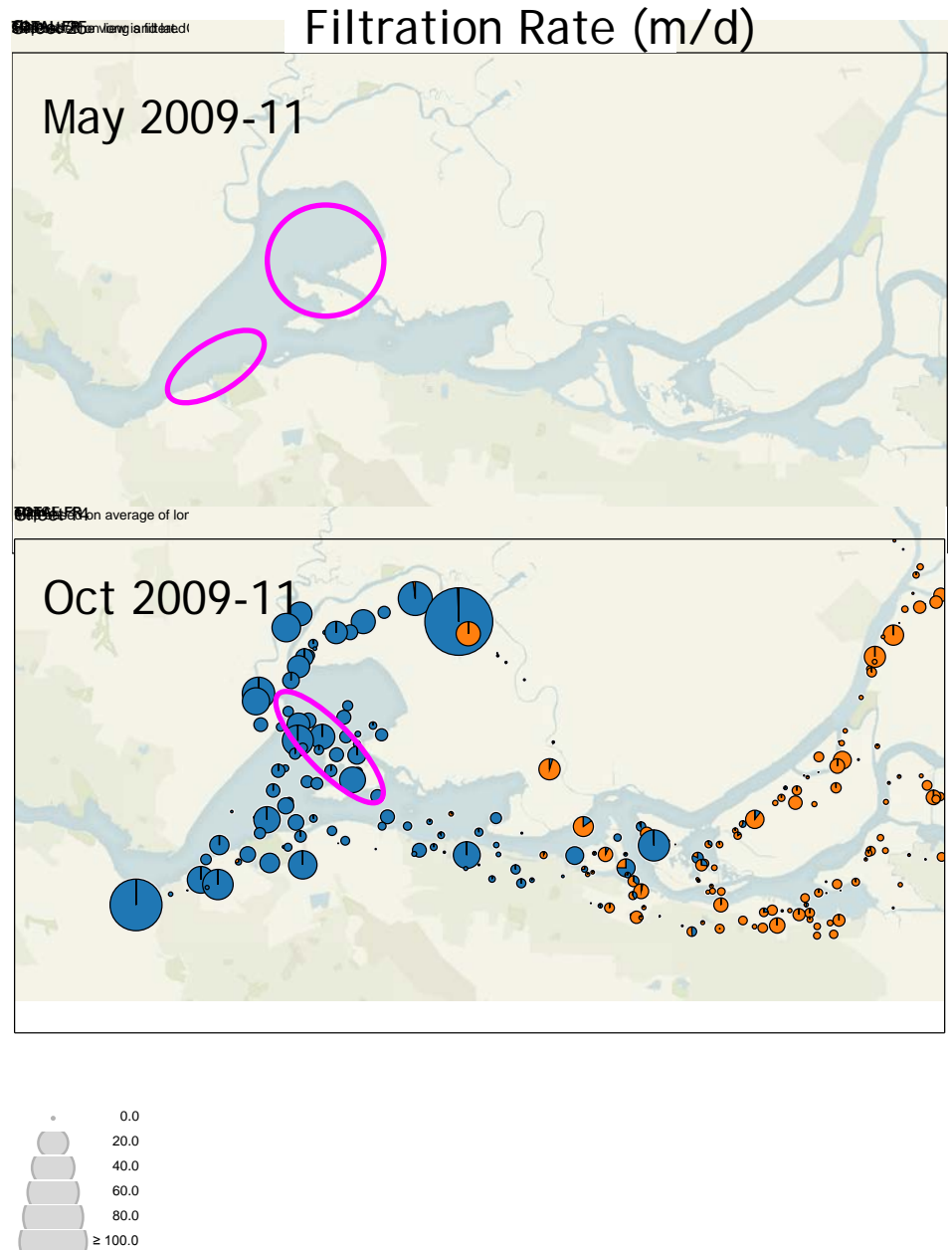
By combining the 2009-2011 GRTS data we see distribution patterns that persist through years and seasons.

1. *Potamocorbula* grazing is greater in fall than spring
2. *Corbicula* grazing rate larger in spring than fall
3. Shallow water grazing rate in Suisun and Honker Bays is very low in spring
4. Grazing rate is lower in the confluence area then upstream and downstream during both seasons.

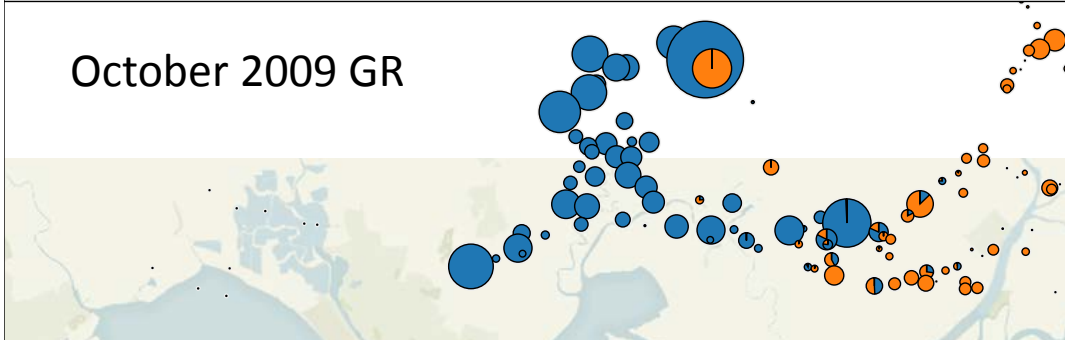


Focusing on the LSZ we
can confirm our previous
observations

*These data also highlight the
variable spatial "strata" needed to
estimate an areal grazing rate in
models. The multiple years of
GRTS are being used to increase
the sample size for each of these
regions.*

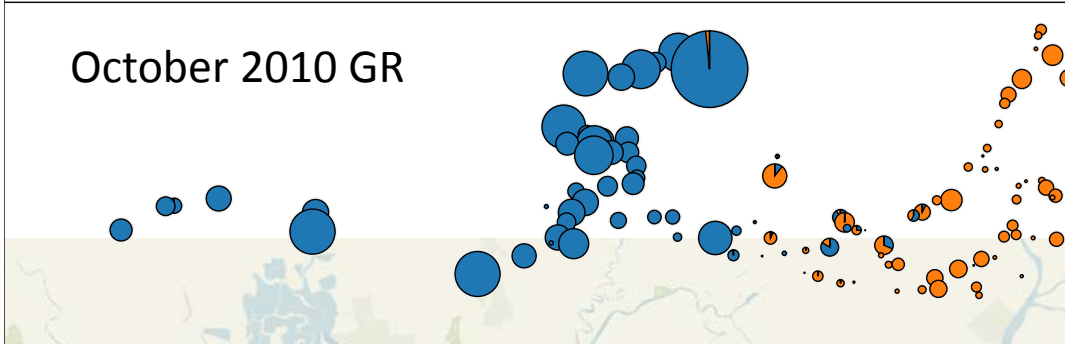


October 2009 GR



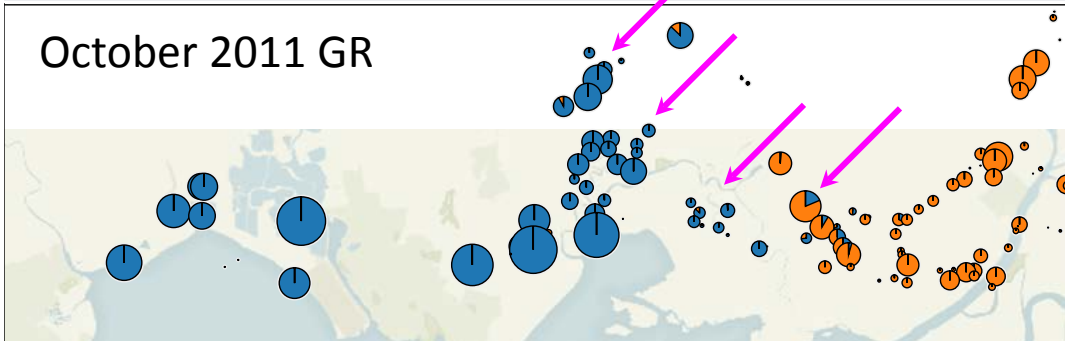
GR LSZ 10

October 2010 GR

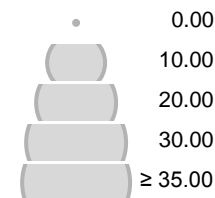


GR LSZ 11

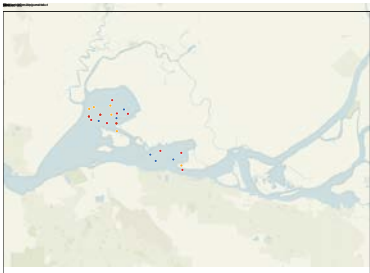
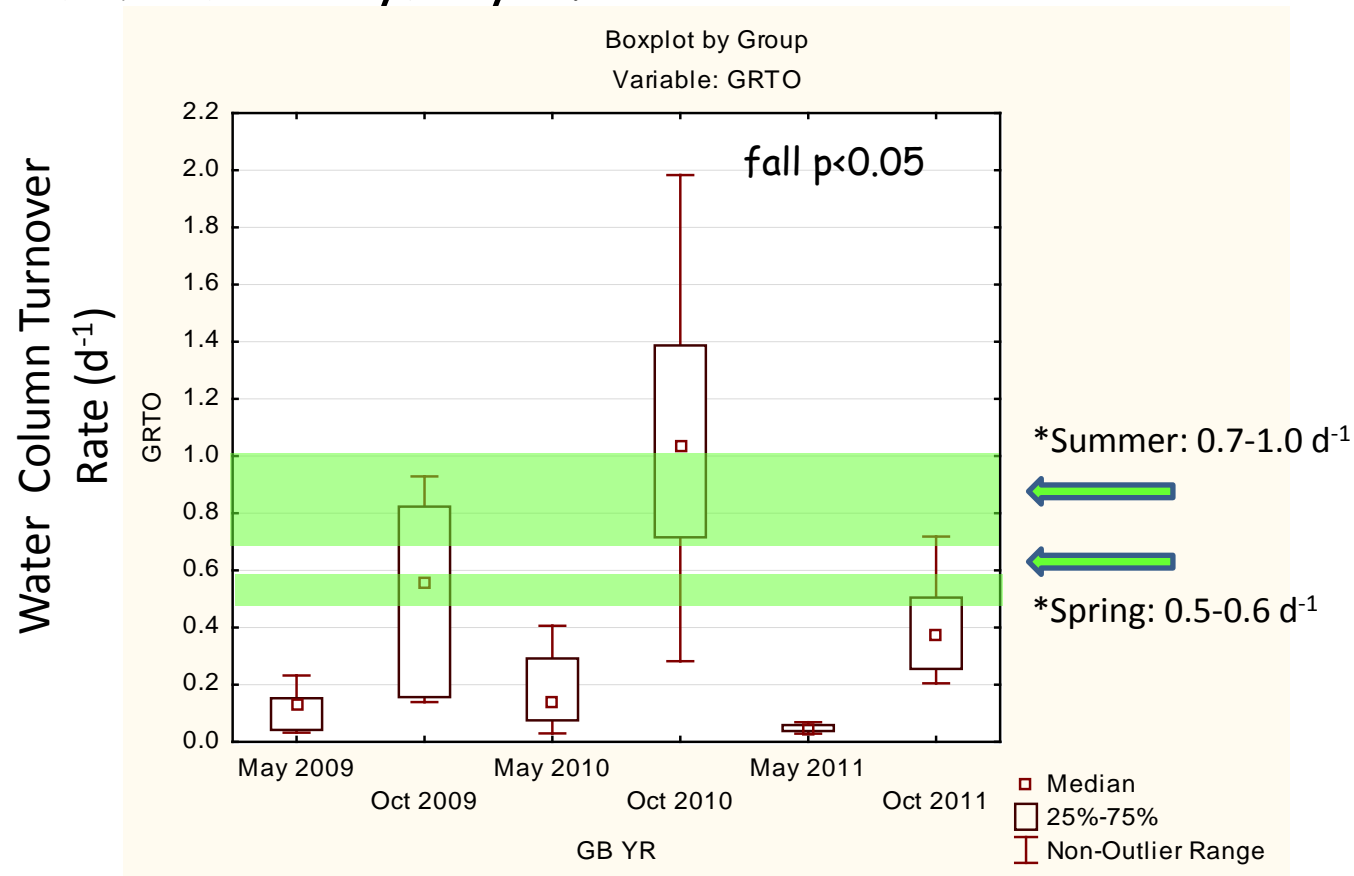
October 2011 GR



Grazing Rate in October for 2001 was lower in the shallows and Suisun Marsh than in 2009 and 2010. Grazing rate was higher at the downstream border of the confluence in 2011 than in 2009 and 2010.



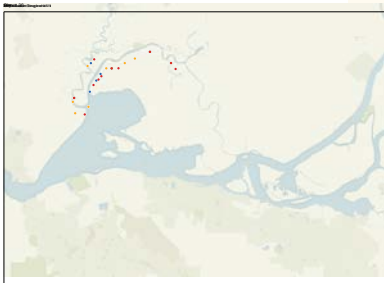
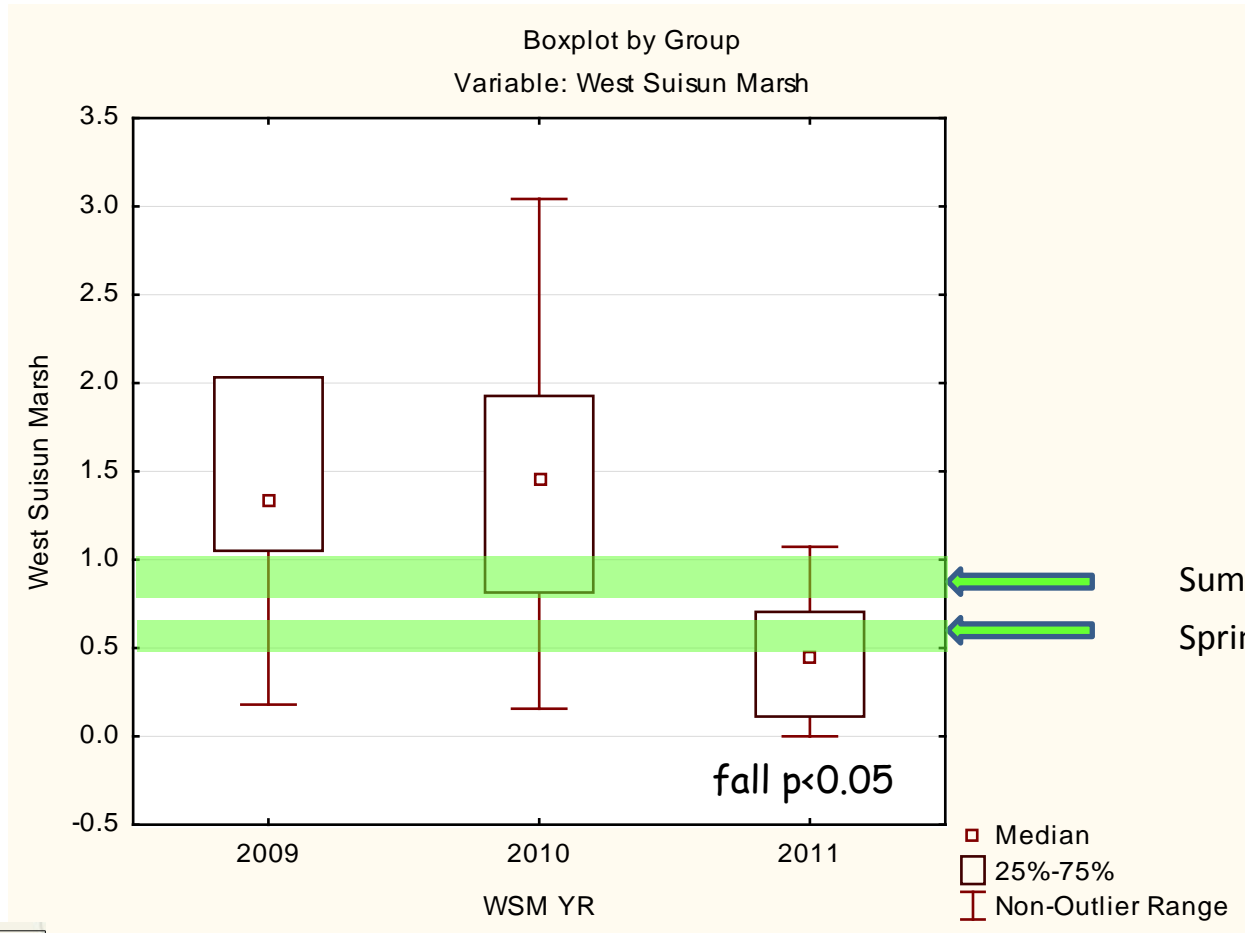
Q1: Was clam grazing rate low enough to reduce pressure on phytoplankton biomass in fall 2011? In the shallows of Grizzly and Honker Bay? - yes.



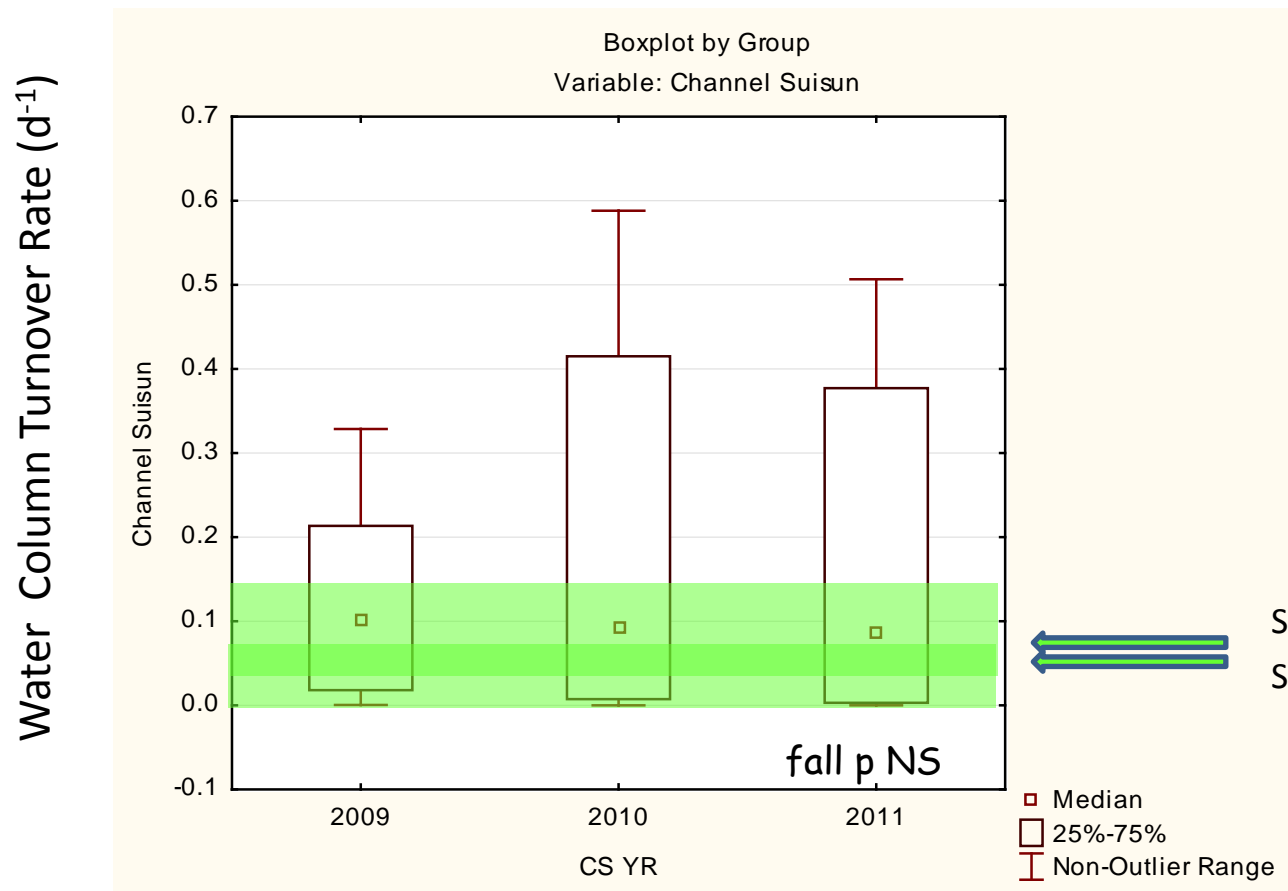
* Based on measured values in 2006, 2007 - Parker et al in press; Kimmerer et al 2012

In October in Montezuma and Suisun Slough? - a very guarded yes.

Water Column Turnover
Rate (d^{-1})

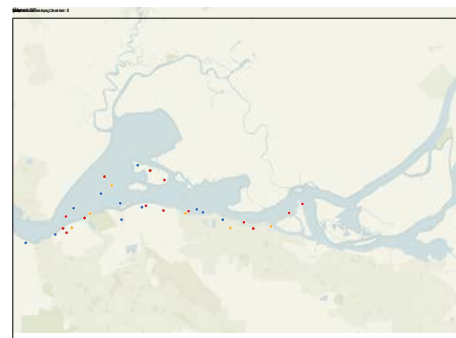


On average, turnover rates were similar to phytoplankton growth rates in Suisun channel in October.



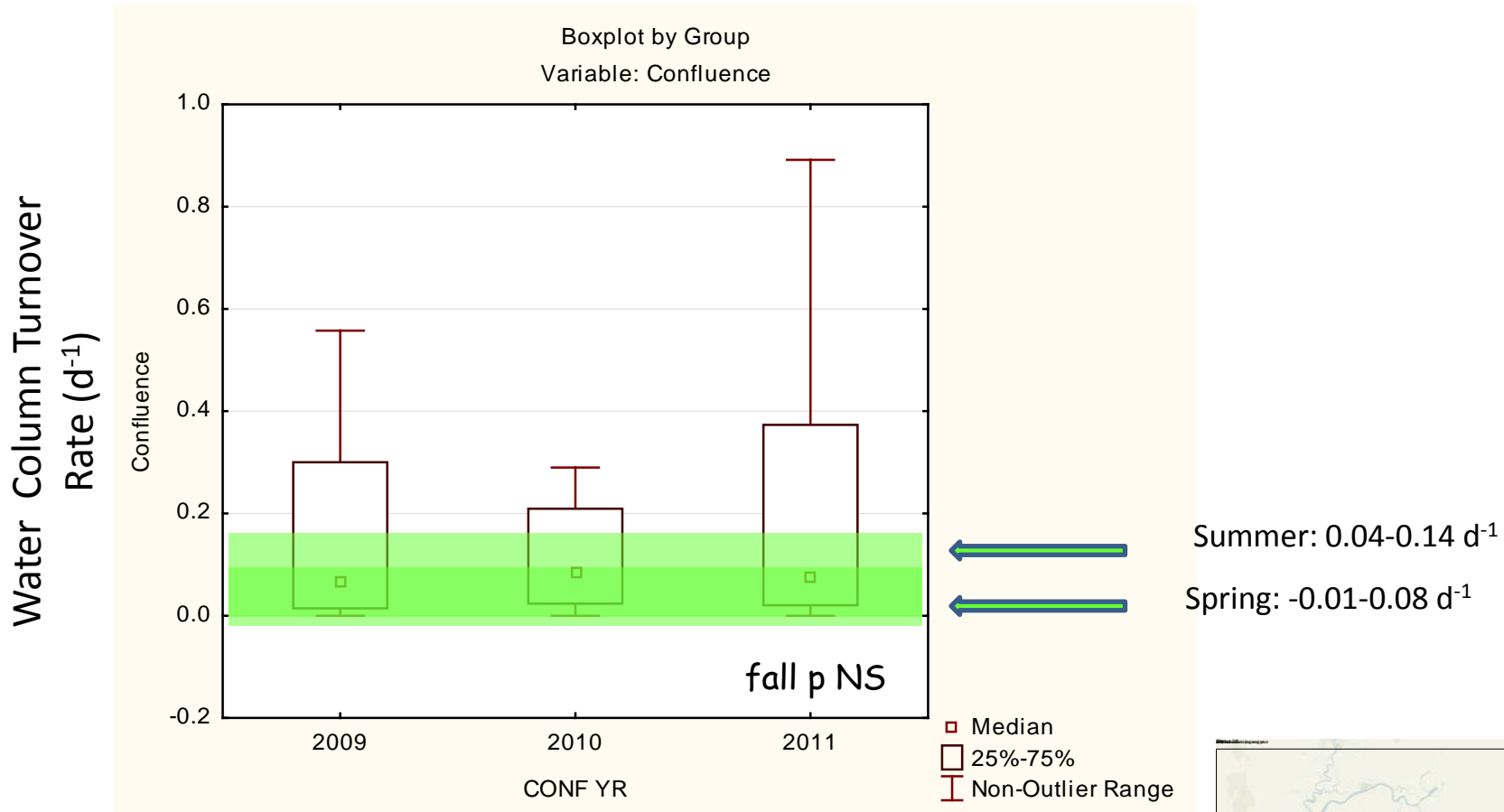
Summer: $0.04-0.14 \text{ d}^{-1}$

Spring: $-0.01-0.08 \text{ d}^{-1}$

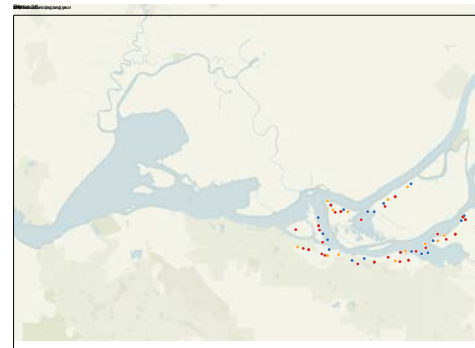


* Parker et al in press; Kimmerer et al 2012

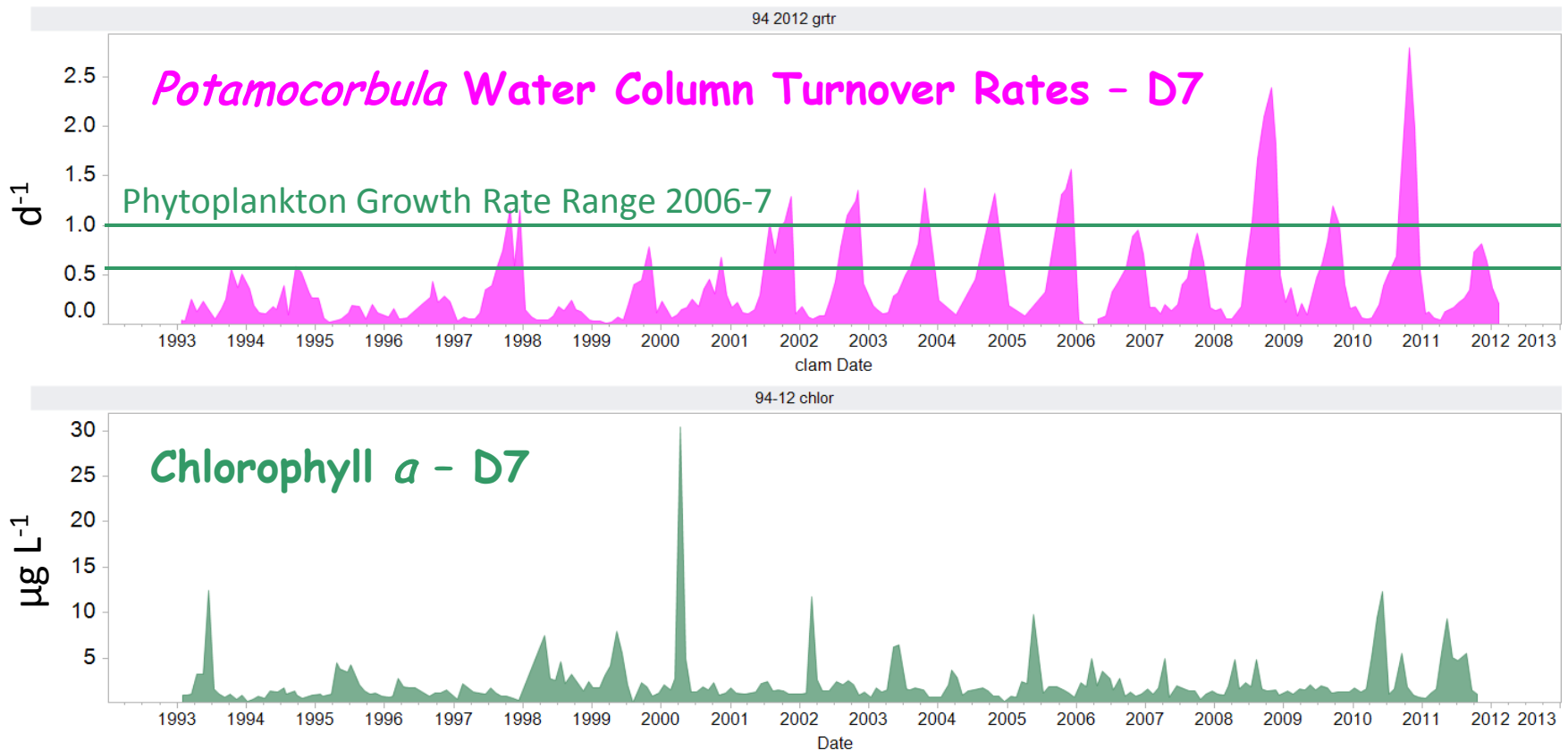
...and in the confluence in October. Note that channel GR could affect microzooplankton.

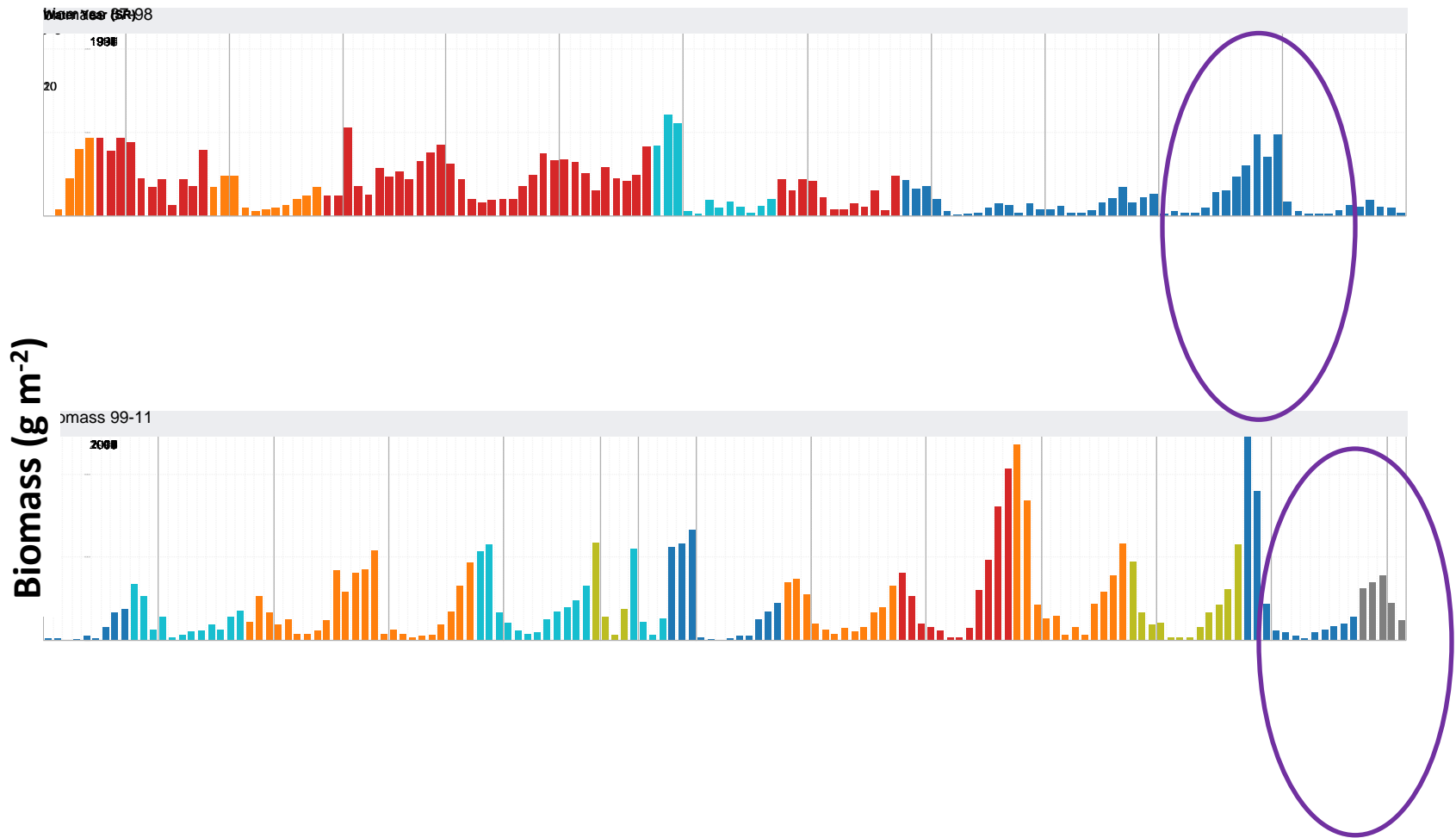


* Parker et al in press; Kimmerer et al 2012



Conclusion: Grazing rates in the shallow phytoplankton growth habitat were low enough to allow a bloom (assuming zooplankton grazing, light, nutrients, residence time are agreeable) in spring of 2009-2011 and fall 2011. The causes of the reduced 2011 fall bivalve biomass are considered next by looking at monitoring station D7 data.





Q2: Was the clam reduction due to spring or fall population dynamics? *Potamocorbula* in 2011 did not have an unusual biomass seasonal pattern or magnitude but the peak was shifted to right. Note the similarity in pattern to that seen in 1997 even though they were preceded by very different water years.

On average, biomass and thus grazing rate slowly increases from the spring minimum in wet years to a peak in fall. The spring grazing rate is greater and the fall increase starts earlier as the years become drier.

This pattern could be result of delayed recruitment, increased mortality or reduced growth rate with wetter conditions.

All Years - Average Monthly Grazing Rate



Wet Years - Average Monthly Grazing Rate



Above Normal Years - Average Monthly Grazing Rate

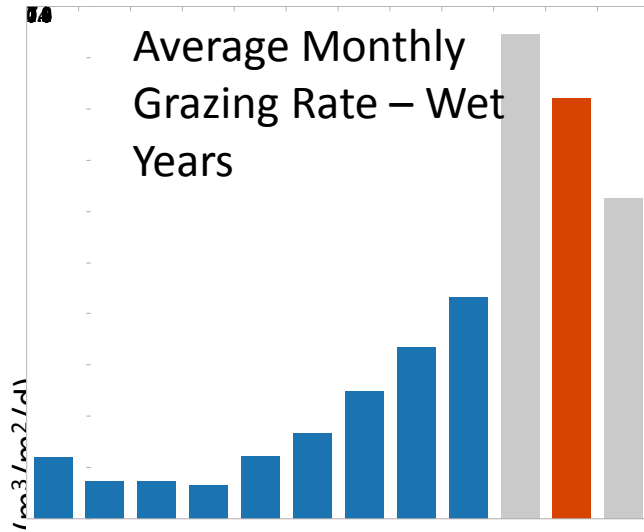


Dry/Below Normal Years - Average Monthly Grazing Rate

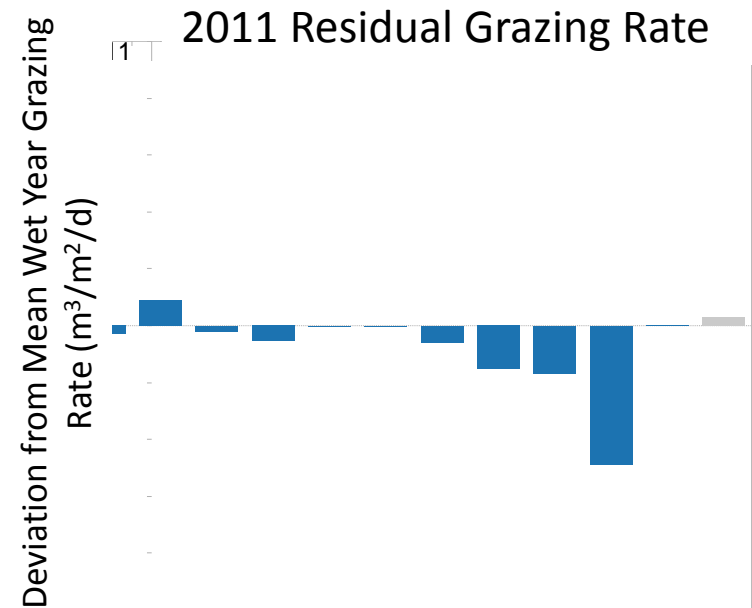
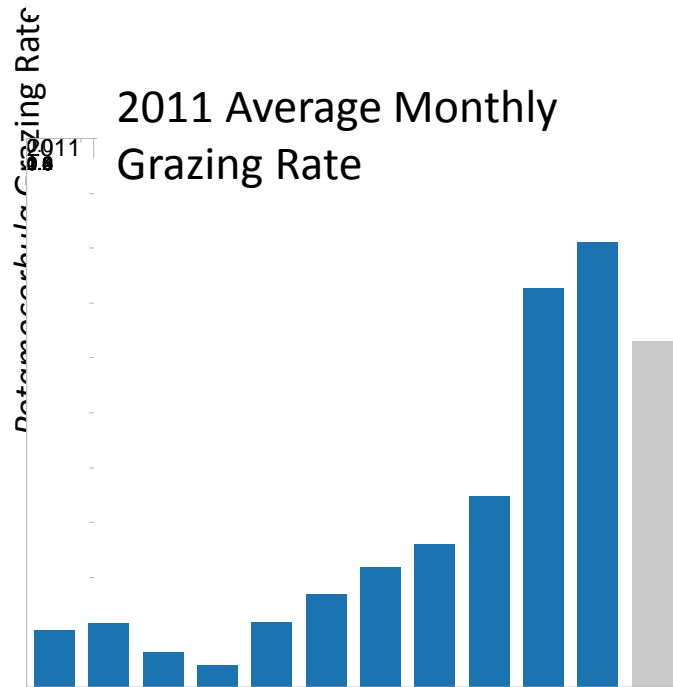


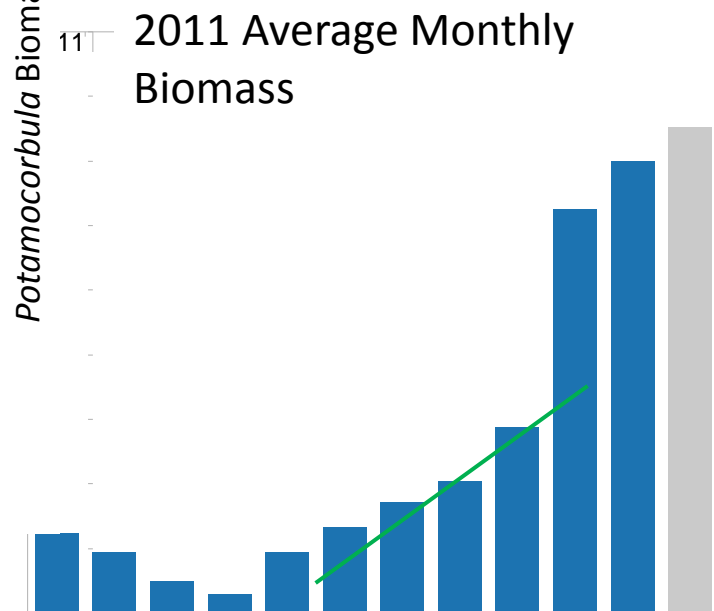
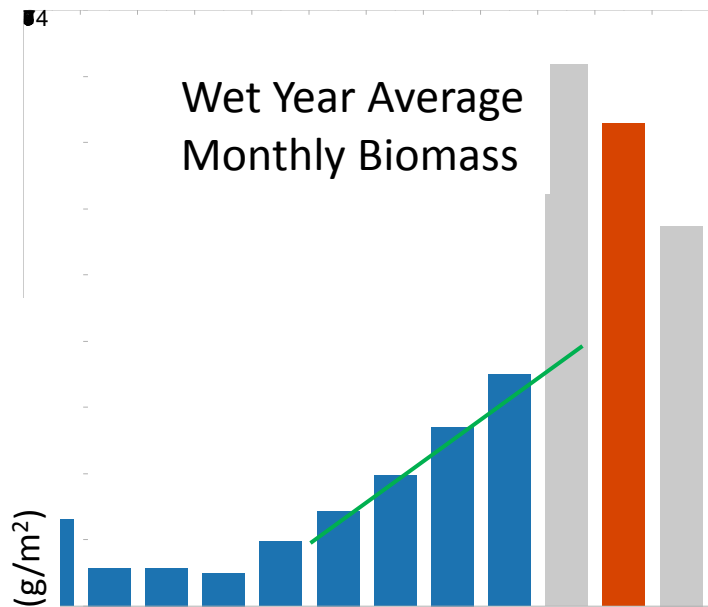
Critically Dry Years - Average Monthly Grazing Rate





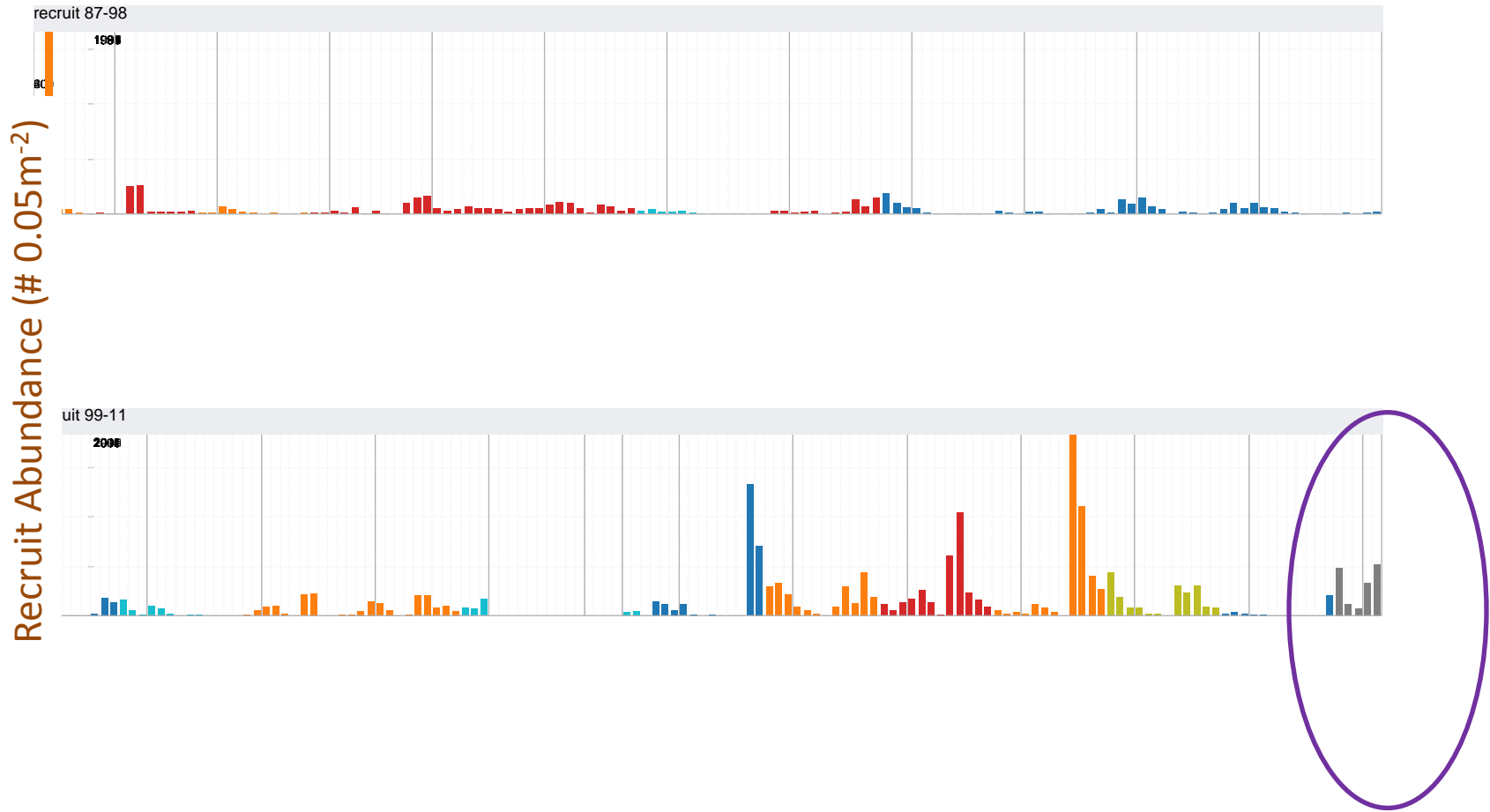
Grazing rate at D7 in 2011 was similar to the wet year average spring grazing rate but lower than the average for early fall.



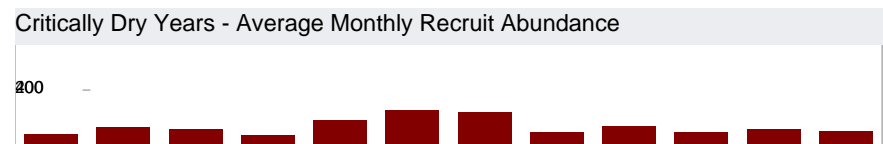
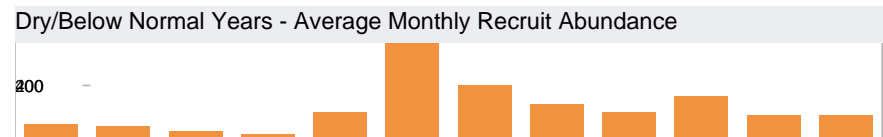
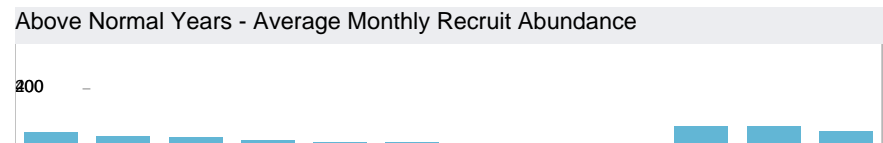
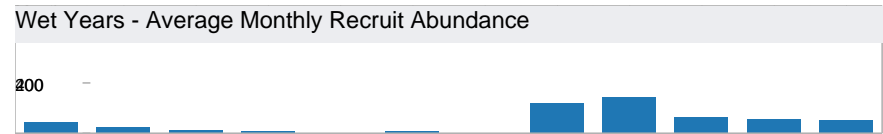


Population biomass growth rate between spring and fall was lower in 2011 (≈ 0.4 g/mo) than the average (≈ 0.5 g/mo). Fall mortality expressed as biomass rate of change was lower in 2011 than during average wet years.

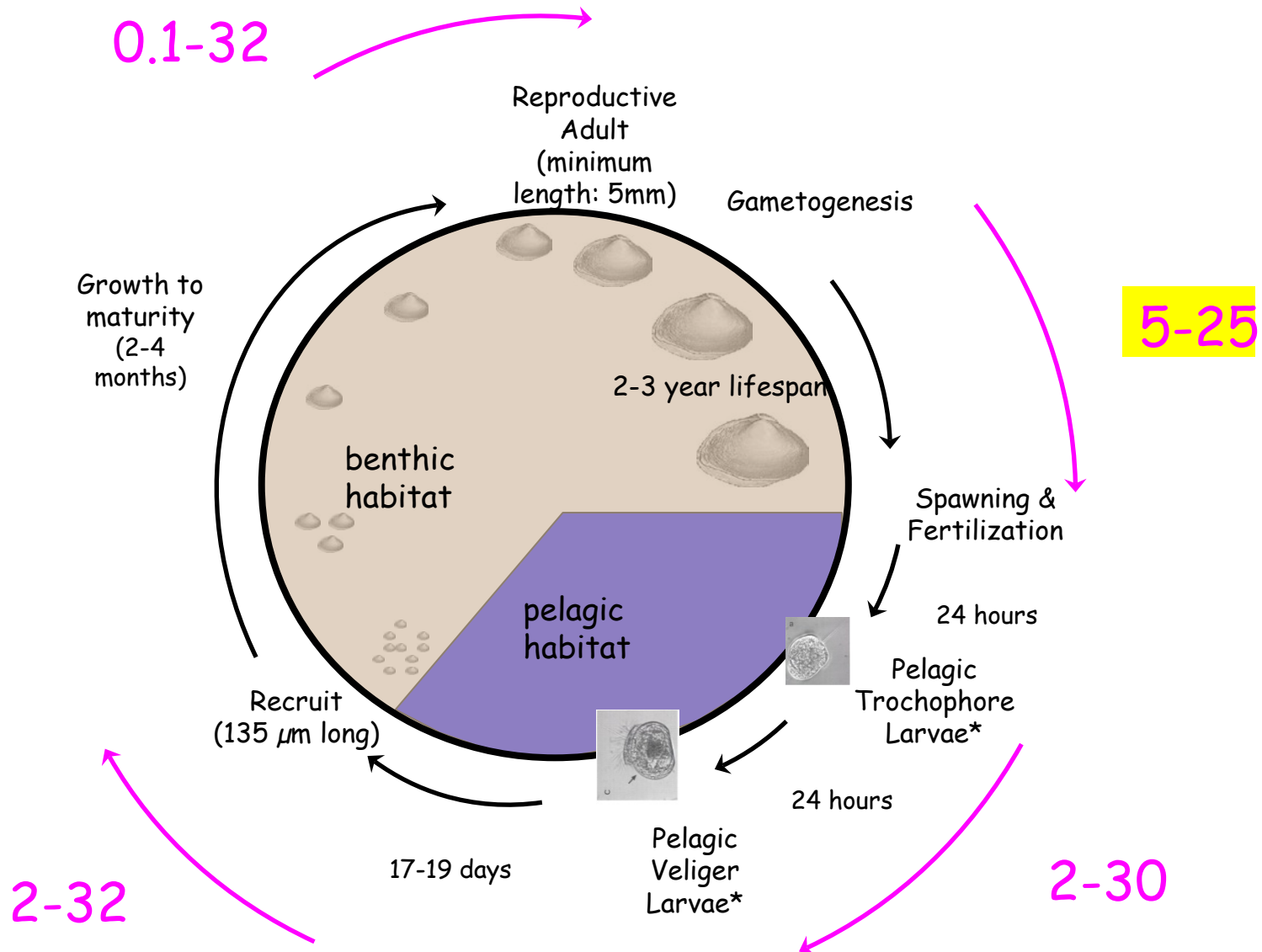
Thus there was a relatively smaller biomass in early fall in 2011 and a larger biomass in late 2011 than the average.

Recruit Abundance (# 0.05m⁻²)

Recruitment pattern is best summarized as monthly average recruit abundance for each water year type. Note the shift to continual recruitment in dry/critically dry years.



The "bottleneck" for recruitment may be the salinity limits on gametogenesis and spawning.

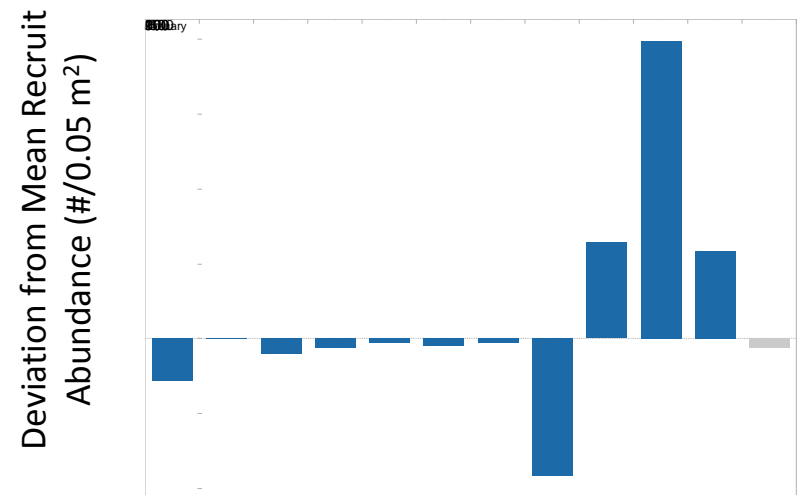




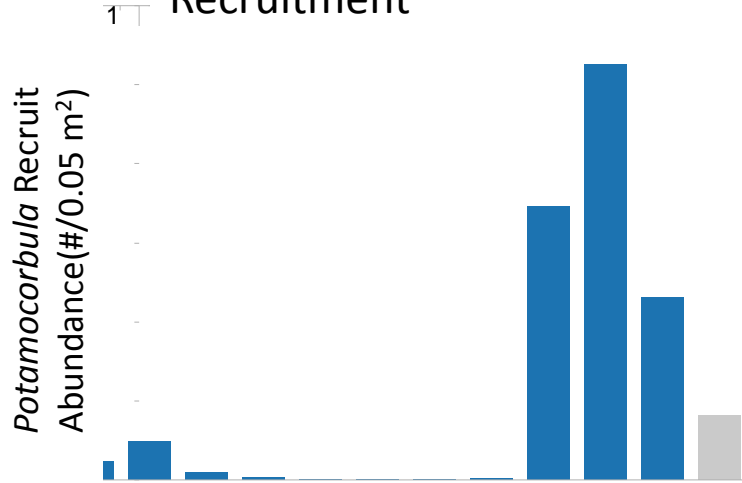
Recruitment at D7 in 2011 was a bit below average in spring 2011, started a month later than the average in fall, and then was way above average in mid fall.



2011 Residual Recruit Abundance

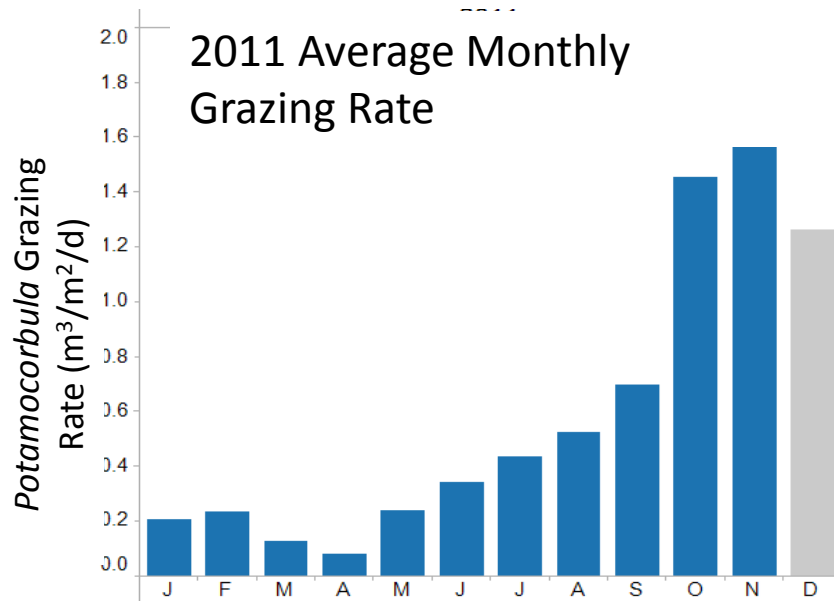


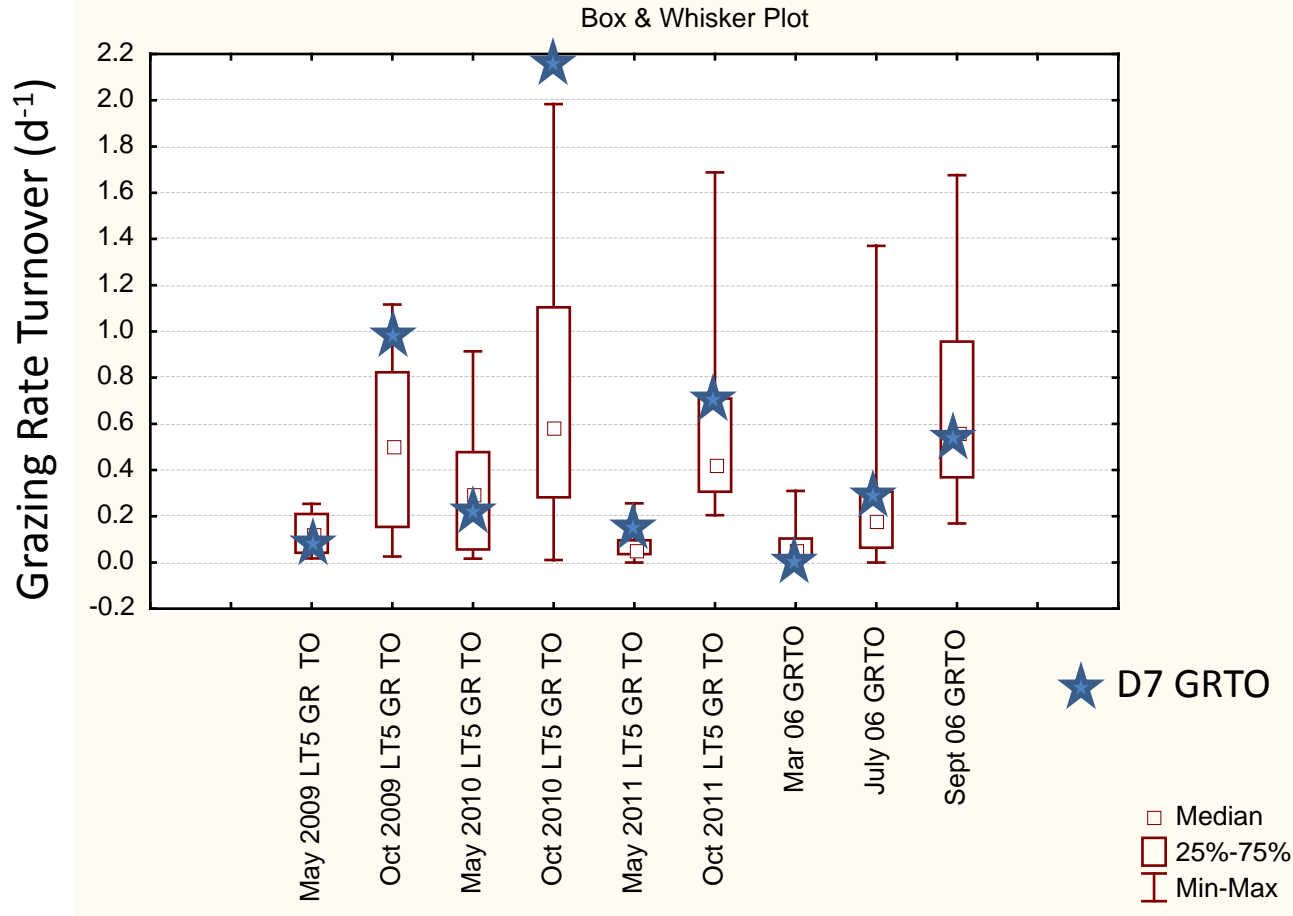
2011 Average Monthly
Recruitment



Biomass and therefore grazing increased rapidly after fall recruitment in 2011. We hypothesize that the lower grazing rate in fall 2011 was at least partially due to late recruitment.

2011 Average Monthly
Grazing Rate



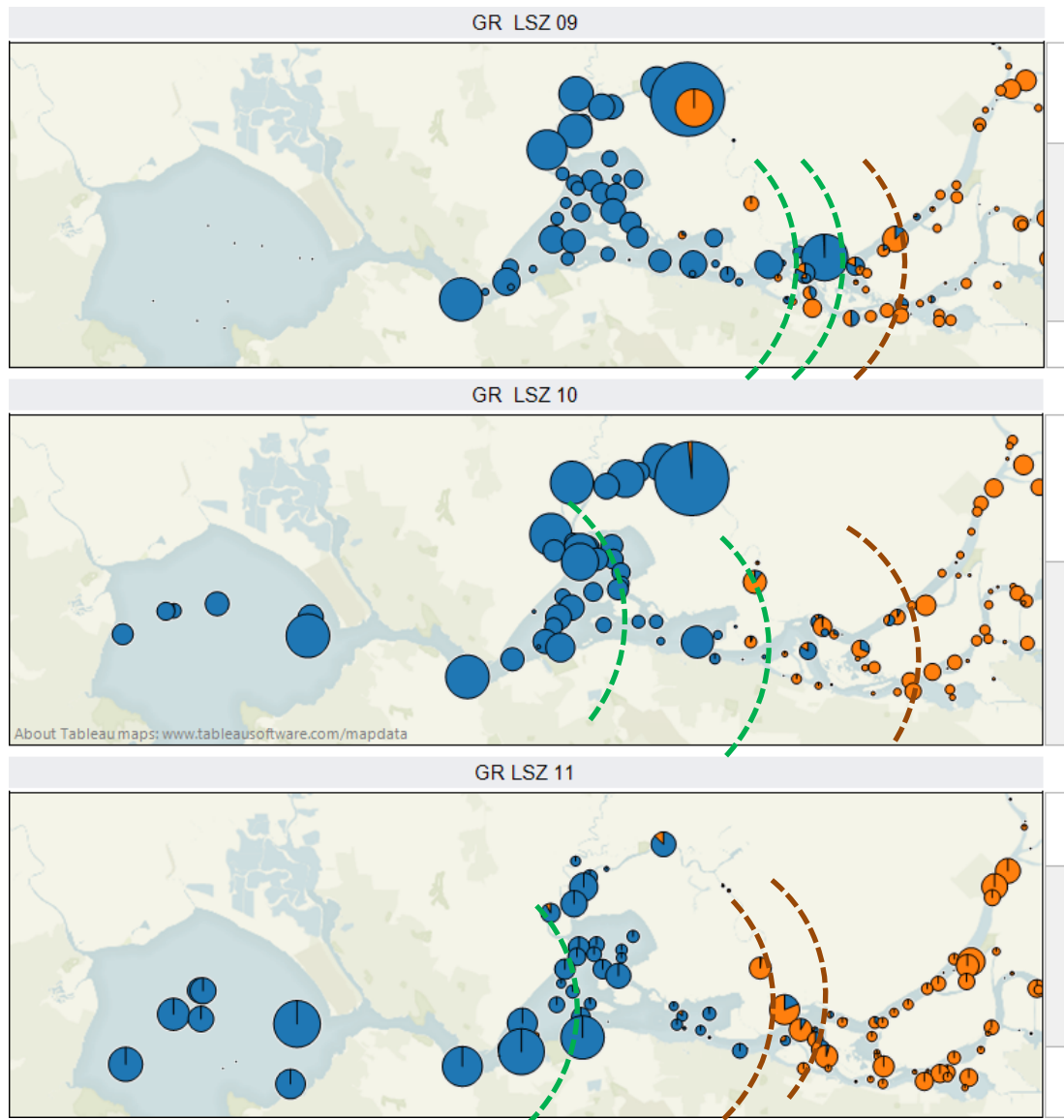
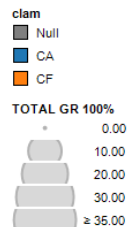


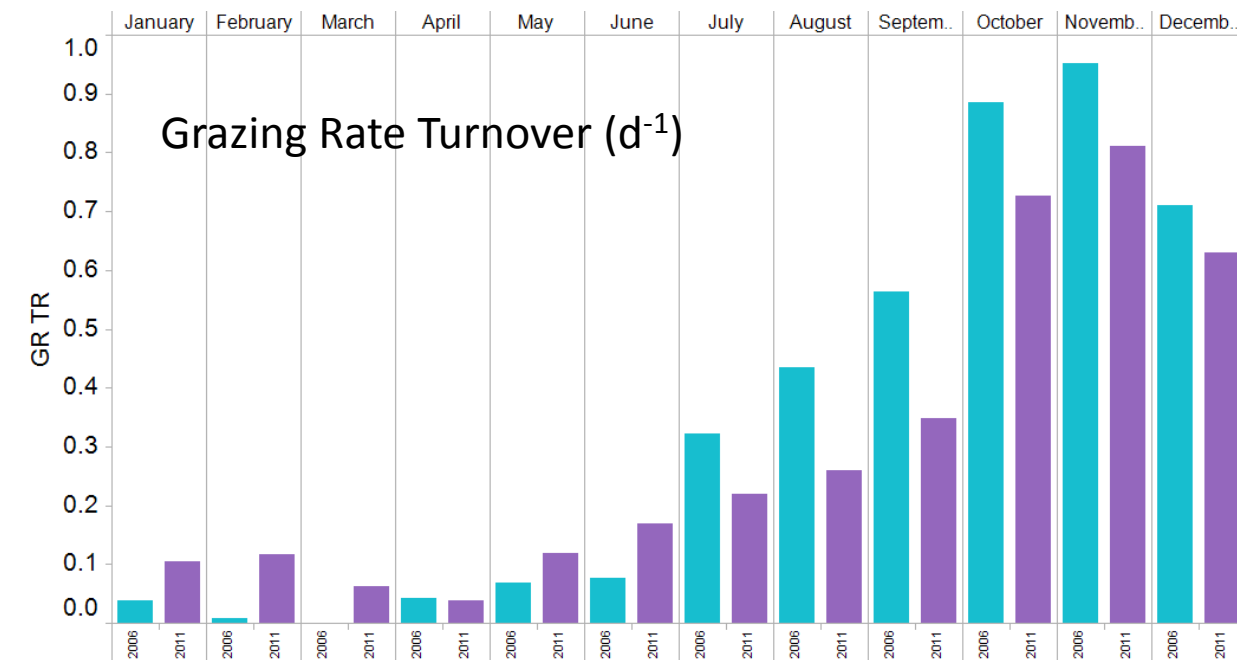
The values of water column turnover rate were similar between the shallow Grizzly/Honker Bay region and D7. We assume the mechanisms controlling the D7 population are similar to those in the region.

Fall grazing rate distribution within the LSZ was consistent with salinity controlling recruitment.

) X2 during fall recruitment

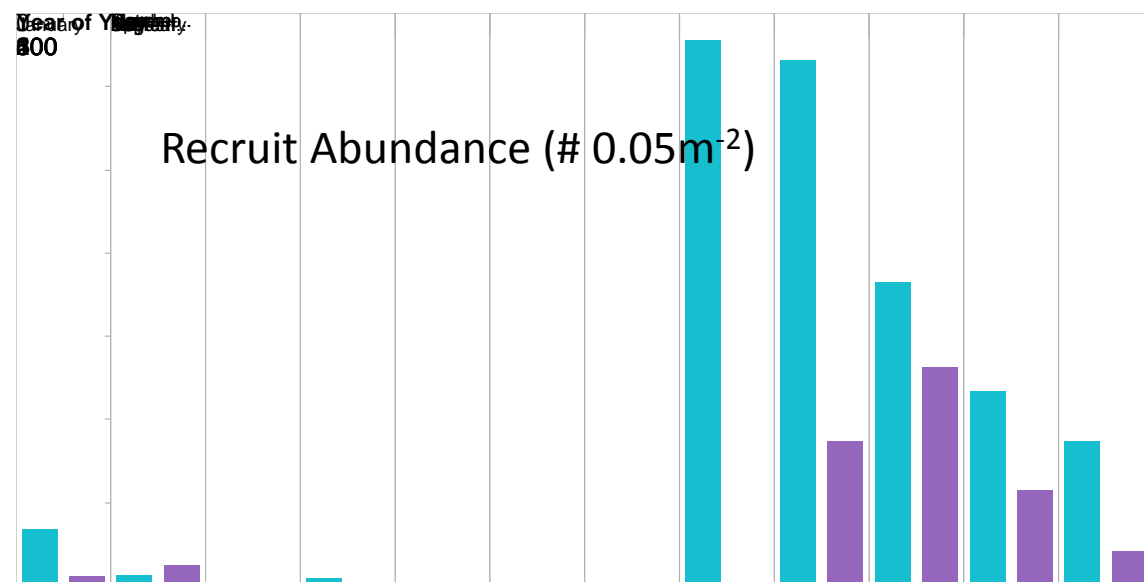
) X2 during spring recruitment





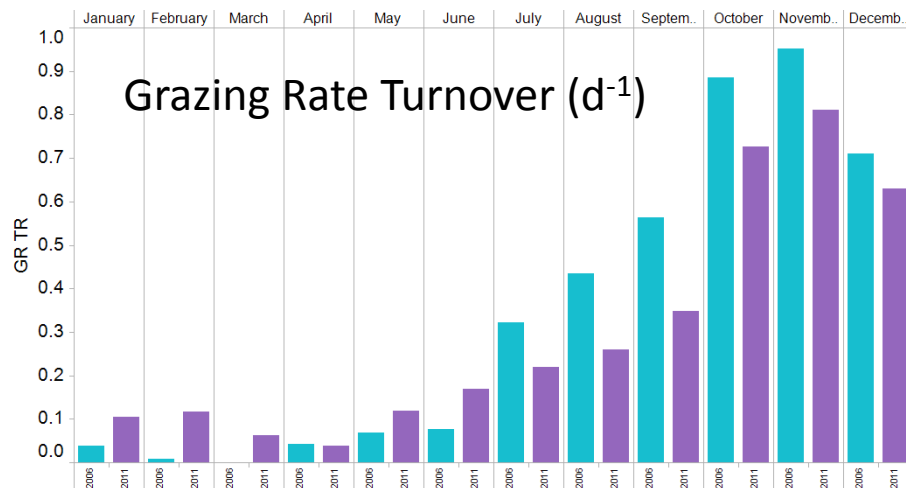
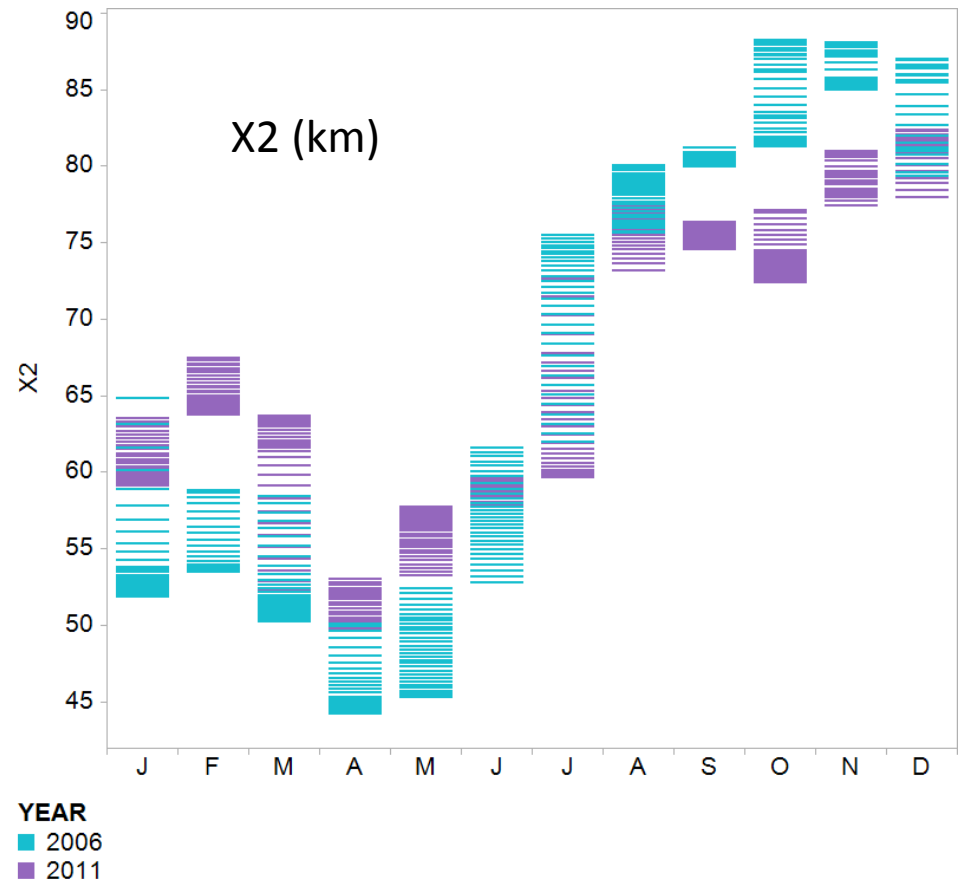
Q3: How did bivalve distribution and grazing rate differ in 2006 and 2011?

There were higher grazing rates entering fall 2006 and an earlier and larger recruitment in 2006 than in 2011.

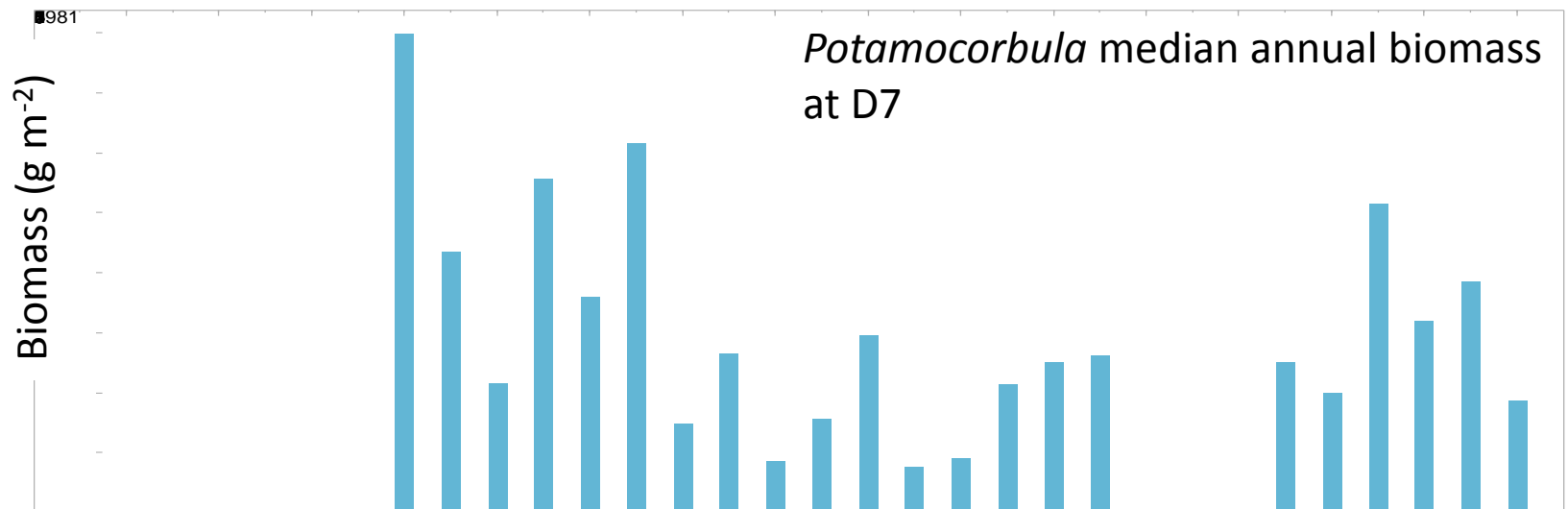
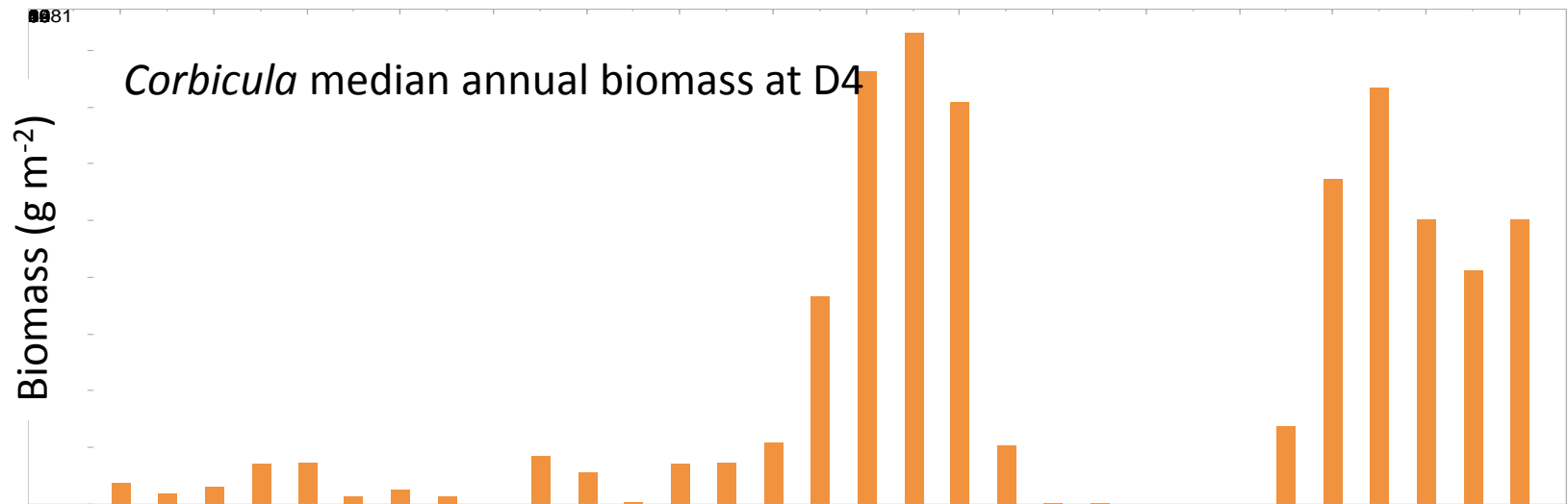


Antecedent effects: Spring GR reflects 2005 above normal water year and 2010 below normal water year.

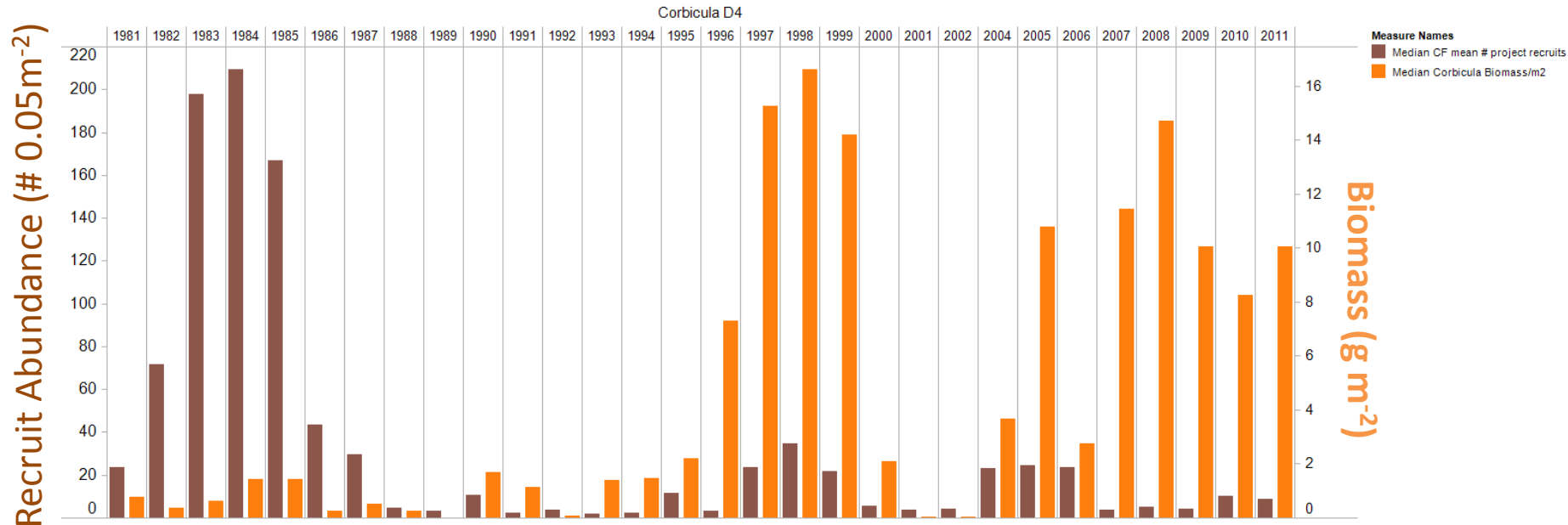
Antecedent effects:
Spring GR reflects
2005 above normal
water year and 2010
below normal water
year.



Although *Potamocorbula* biomass has remained variable, it has not shown a trend after the initial invasion years. However, *Corbicula* at the confluence (D4) has greatly increased its biomass.



Although *Corbicula* recruit abundance has declined with the increase in biomass, the recruits are constantly present at D4 and many other locations. What caused *Corbicula* population structure to shift? Has this happened at other locations?



Median CF mean # project recruits, Median Corbicula Biomass/m2 and Median Corbicula Biomass/m2 for each biomass date Year. Color shows details about Median CF mean # project recruits and Median Corbicula Biomass/m2. The data is filtered on Corbicula Biomass/m2, which ranges from 0 to 139.07758964.

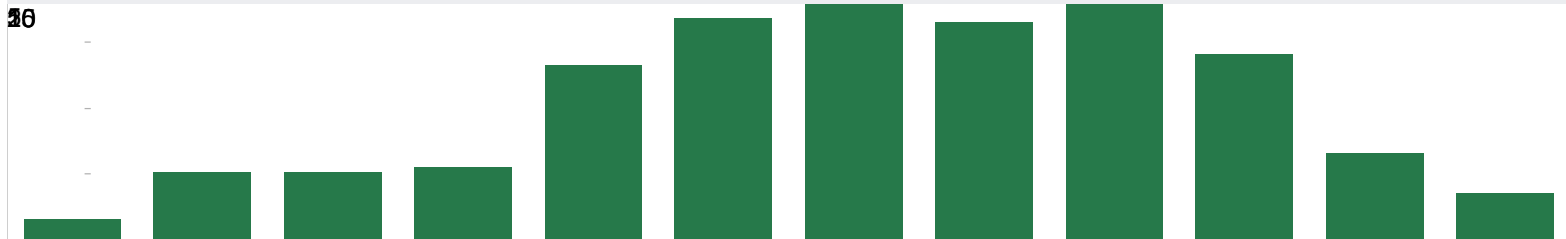
Plans for the future:

1. Process and analyze 2012 GRTS - the only Wet-Dry combination sampled for GRTS was in 2011 and 2012
2. Process and analyze monitoring station data for 2012
3. Complete analysis of monitoring station data to confirm/refute conclusions from D7 and D4 analysis.
 - Would the presence of summer recruits have changed our result? Is that a possible outflow combination?
 - Secondary production, growth rate and mortality rate are being estimated for some USGS/DWR stations to confirm our findings
 - Expand analysis to examine *Corbicula* population dynamics in the "dispersion" zone. Is it true that *Corbicula* biomass peaks in spring which is opposite to that of *Potamocorbula*? How significant is that in the dispersion zone?
 - Does magnitude of spring population matter in fall?
4. Establish protocol for estimating regional grazing rates for numerical models using the fullest set of GRTS samples available: adding 2007, 2008, 2012.

Thanks to BOR for the funding opportunity and to DWR for working with us.

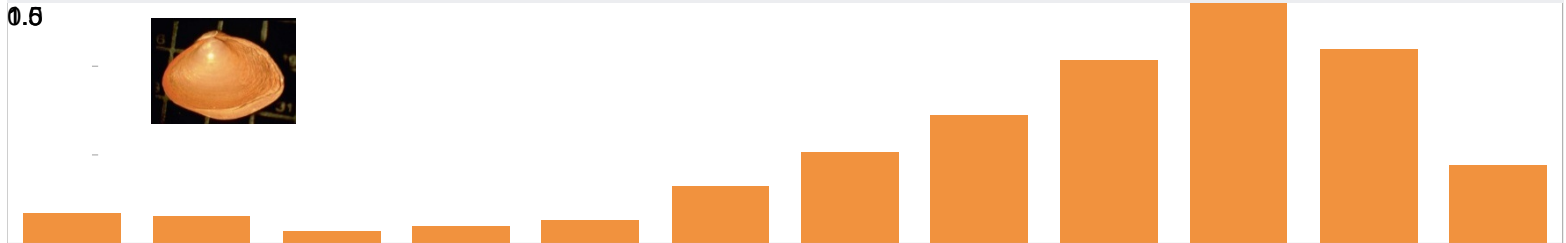
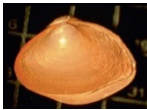
1975-1986 Chlorophyll a

16



1987-2011 Grazing Water Column Turnover Rate

0.6



1987-2011 Chlorophyll a

16

